Ten commandments for implementing clinical information systems

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The need for electronic health care information systems is entering into public debate. In his 2004 State of the Union address, President George Bush called on the health care industry to adopt electronic medical records, stating that such technology could "avoid dangerous medical mistakes, reduce costs, and improve care" (1). With its plans to spend $119 million over the next 7 years on information systems, Baylor Health Care System is joining a number of other systems around the nation that are currently involved in such efforts. For example, the Fremont Area Medical Center began implementing computerized physician order entry (CPOE) in January 2004 (2); the Sisters of Charity of Leavenworth Health System began implementing CPOE in October 2003 (3); Aurora Health Care of Milwaukee is investing $75 million over the next 3 years in technology including CPOE (4); and Athens Regional Medical Center is making CPOE a component of a decade-long technology effort (5). Overall, information technology expenditures in health care totaled $21.6 billion in 2002. Expenditures are projected to increase every year: to $23.6 billion in 2003, $25.8 billion in 2004, $28.0 billion in 2005, and $30.5 billion in 2006 (6).

At Cedars-Sinai Medical Center in Los Angeles, I have been involved in implementing clinical information systems for 10 intensive care units (ICUs), labor and delivery, and the emergency department (between 1991 and 2002), as well as a web-viewing system containing all inpatient and outpatient medical record information (in 1998).

Cedars-Sinai was an early implementor of the first wireless personal digital assistant devices in 1999. All clinical data can be accessed remotely. The hospital is totally wireless with a securely encrypted system. While the hospital made an investment in technology that is very similar to what Baylor is planning, it does expect to see a cost savings from the efficiencies obtained. Nevertheless, components such as clinical information systems are planned not as cost-saving measures but as quality improvement measures.

In this article, I share a summary of our experience and focus on 10 of the most important lessons, or "commandments," learned during the implementation of our clinical systems *(Table)*.

Table. Ten commandments for clinical information systems

1. Speed is everything.
2. Realize that doctors won't wait for the computer's pearls.
3. Deliver "just-in-time" information.
4. Fit into the user's workflow.
5. Respect physicians' sense of autonomy.
6. Monitor implementation in real time and respond "right now."
7. Beware of unintended consequences.
8. Be wary of uncovering long-standing process flaws.
9. Don't disrupt "magic nursing glue."
10. Speed is everything.

1. SPEED IS EVERYTHING

Multiple authors have found that terminal response time is the parameter most highly valued by clinical users. If department store cashiers, for example, have to suffer through cumbersome point-of-sale information systems, they are paid to do that—it is part of their job. Health care professionals do not like to work that way and physicians are typically not directly employed by hospitals, so speed has to be key. Users don't care as much about beautiful screen design, features, advice, warnings, or alerts—however important those elements may be and however much they are highlighted by the vendor. During day-to-day utilization, what users want is subsecond screen flip response times.

Achieving this response time can be a challenge. During focus groups with users in 1990 conducted by the vendor of Cedars-Sinai's ICU information system, vendor engineers asked whether 5 seconds, 2 seconds, or 1 second would be an acceptable response time to flip screens. The users' response was unanimous: the screens needed to change even more quickly—as fast as a blink. It took the engineering group 2 to 3 years to make the screens operate at "blink speed," but eventually they did. Now, if you come to a Cedars-Sinai ICU, you can see how users can

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Note: A PDF file of Dr. Shabot's PowerPoint presentation, which includes screen shots from the Cedars-Sinai clinical information system, is available at www.BaylorHealth.com/Proceedings under issue 17(3).

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go from a patient's monitored data flowsheet to a ventilator flowsheet to an intake-outtake flowsheet in a split second, or as fast as they can point and click. Switching to another patient may take 2 seconds, but after that, the user is back to a "blink" response time for that patient. No one argues with "blink speed"; we've learned that lesson well.

All successful clinical information systems are fast. Many of the most successful systems were developed in-house, and most of those still run in DOS. It has proven to be difficult to make a Windows system operate as fast as users want it to.

2. DOCTORS WON'T WAIT FOR THE COMPUTER'S PEARLS

Physicians might wait for a learned elder to share a "pearl" of information with them, but they won't wait for the computer to do so. This can be a problem because medical staff leaders, administrators, and trustees view the clinical information system primarily as a way to improve quality and control costs. Those are important goals: the Institute of Medicine report, *To Err Is Human,* has indicated that 44,000 to 98,000 patients die each year in US hospitals, mostly due to preventable errors, often drug errors (7). Consumers are very aware of this information as well. Yet improving quality and controlling costs require the system to look up data (which costs the system time) and present the additional information to users (which costs users time). With the clinical users' priority being speed, this plethora of "extra" information can be seen as irritating.

Let me give a typical example from a CPOE system. If the physician orders amiodarone and the patient is already taking digoxin, the CPOE system checks its database and notes an interaction: amiodarone increases the effectiveness of digoxin. If the physician needs more information, the CPOE system can provide a hotlink to access a monograph on the drug interaction. This information access appears to be a wonderful tool to improve quality care. However, many if not most drugs have many interactions with dozens of other drugs and sometimes over 100 other drugs. Physicians safely prescribe these drugs every day without giving much thought to these interactions, and it's not really possible to tell the system that Dr. Smith does not want to be bothered with such information today. The physician will need to acknowledge and sometimes override the alert, which occurs repetitively every time the drug is ordered. Alerts frequently take away from the blink speed that physicians want. Alerts that appear every time a physician orders a common drug can become downright annoying.

One hospital's solution for CPOE was to show drug interaction alerts only to pharmacists as they verified medications. The hospital implemented this change when physicians complained about the slowness of the system after a few weeks of use. It is tedious for pharmacists as well as for physicians to review interactions, but pharmacists are paid by the hospital to do this work and are much more proficient at it than physicians.

3. DELIVER "JUST-IN-TIME" INFORMATION

A commonly held educational theory is that people are particularly receptive to learning new information when it is delivered to them right when they need it. A surgery resident, for example, may be particularly open to learning about the intricacies of a disease process a day or two before an operation on a patient with that disease. Providing the information 2 weeks before or 2 weeks after the operation would not have the same effect. Samuel Johnson observed in 1770 that "men more frequently need to be reminded than informed." Professionals don't mind being reminded, but they don't like being informed all the time. It is important, then, to anticipate user needs and deliver information when it's needed and wanted.

One example of just-in-time information comes from the BICS system used by Brigham and Women's Hospital (8). The 12-year-old system is DOS based and is very fast. When a physician orders digoxin, the system not only gives a choice of doses but also automatically brings up the patient's most recent serum potassium level. The physician does not have to do anything with the information but may want to.

At Cedars-Sinai Medical Center, we have focused our "just-in-time" information on the core measures of the Joint Commission on Accreditation of Healthcare Organizations (JCAHO). One such measure is administration of the pneumococcal vaccine to eligible patients prior to hospital discharge. When a patient is eligible for this vaccination, the system can send an alert to the physician; the physician can then click on the hotlink and see the specific recommendation and the evidence behind it. This alert effort is in its early stages but is beginning to be effective.

4. FIT INTO THE USER'S WORKFLOW

There is a temptation to use a new system to "improve" clinicians' workflow. As the saying goes, "Don't just computerize a process; improve it," and there is truth to that. However, system developers need to realize that computerization may in some instances slow down clinical processes rather than improve them.

The goal should be to ensure that the clinical information system is in tune with health care professionals' existing processes and workflow. The Cedars-Sinai web-viewing system was designed to show, upon log-in, all the patients who have been admitted to the physician or for whom the physician is consulting. We decided to first show users new data, with the most recent results at the top. For my patients, I may find blood gas results, followed by a note about a consultation report (with a hotlink to the report), a note about a radiology report (with a hotlink), and routine blood count results. No searching is required, and the instruction needed to use the system is minimal. Although training classes were offered to physicians, none needed them. All of our chemistry and other flowsheets are available through the system, as well as echocardiograms, electrocardiograms, and radiology images—computed tomography scans, magnetic resonance images, and chest and other plain images. Parts of the hospital's medical record, including images, have been totally digital for about 2½ years.

Our goal was to optimize the presentation of information to minimize the time required by the user to access the system. The system has been highly successful. Usage has now reached more than 46,000 pages viewed per day, up 10,000 page views from 12 months earlier. The system covers all inpatients and all outpatients and has virtually eliminated the need to pull an old chart, because data for the past 8 or 10 years is available in the system—data predating design of the web-viewing system itself.

5. RESPECT PHYSICIANS' SENSE OF AUTONOMY

Physicians don't have an easy life these days: they are under scrutiny from regulatory bodies such as JCAHO, face numerous hospital policies, deal with gatekeepers, have problems related to reimbursement, and face piles of paperwork at the end of their day. They deal with credentialing, licensing, quality initiatives, and medical liability. Physicians frequently feel like they're under attack, a finding revealed through numerous surveys from bodies such as the American College of Surgeons. With this health care environment, a new clinical information system can add to the paranoia and be seen as one more imposition on practice autonomy.

While most physicians—certainly the young physicians and the trainees for the last 10 years—are very computer literate, some senior physicians are not. These senior physicians may be among those in leadership positions. Ultimately, when you convert from paper reports to digital files, there's no choice but to use the computer system. In some cases computer use has been made optional. El Camino Hospital in Northern California established its CPOE system 21 years ago and made it voluntary; now, approximately 60% to 70% of orders are computerized and the other 30% to 40% are handwritten.

Autonomy is an issue even with the drug alert feature of the CPOE as discussed above. If a patient indicates an "allergy" to codeine, in most cases this represents a "sensitivity" or a reaction to the drug rather than a true allergy. Sometimes patients just don't like the way codeine makes them feel. However, with most CPOE systems the physician would subsequently have difficulty prescribing adequate pain relief. All morphine-derived drugs would be linked to codeine in the drug database, so the physician would be presented with an allergy alert when ordering any other narcotic medications. Especially when these drugs need to be prescribed frequently, the repetitive "false alert" is cumbersome. These alerts are time-consuming to override because an override reason has to be chosen or typed in and the physician's electronic signature added. A recent study reported that "related-drug" CPOE alerts were false or not useful about 95% of the time. Writing an order by hand takes a couple of seconds, and the paper doesn't slow down the physician with alerts.

In 1834, the following quote appeared in the *London Times:* "That it will ever come into general use, notwithstanding its value, is extremely doubtful because its beneficial application requires much time and gives a good bit of trouble, both to the patient and to the practitioner." The statement refers to introduction of the stethoscope into medical practice but could also apply to CPOE.

6. MONITOR IMPLEMENTATION IN REAL TIME AND RESPOND "RIGHT NOW"

Most clinical information systems on the market today are striving to become adequate if not good. It is difficult to find a real user who will tell you that a particular system is great. The salesman will tell you that the system is fantastic and everybody loves it, but still in real life the available systems are striving to become adequate. Nevertheless, technology is not the main issue. Far more important is the process of implementation: issues such as how a system is phased in and how the staff are prepared for it.

"Change management" is about people, not about computers. Those who have had success with their way of doing something will be hesitant to try a new process. This is especially true in health care, where patient lives are at stake. Physicians may not perceive any difficulties looking up information on paper or writing orders by hand. They may understand the general value to society of avoiding drug interactions, drug allergies, and other medication errors, but they may not think this applies to them or their practice. Without a reason to change, physicians are reluctant to change.

Implementation of clinical information systems costs much more than the hardware and software itself—or at least it should. When nurses and pharmacists receive training, which typically requires one or more dedicated days in class, staff have to be brought in to fill in for them. That is expensive and has to be considered part of the implementation cost rather than a routine nursing or other cost. Partial implementation of clinical and CPOE systems in a hospital is difficult, since many patients transfer every day from one unit to another, whether it's a step-up unit, step-down unit, ICU, or procedural area. Transfers can be awkward when one area is computerized and another is not.

The implementation timeline (and therefore the budget) is very difficult to estimate accurately. Because so much money is involved, hospital administration wants accurate numbers and wants the implementation to remain on budget and on schedule. At Baylor, this would certainly be the management's expectation for construction of a similarly priced $119 million building. However, implementation of clinical systems is very different from construction, even though the price tag may be the same. Unforeseen glitches will occur, fixes will need to be made, and additional training may be required. Sometimes a system will work flawlessly in one area of the hospital but poorly in another due to differences in workflow, staff, or patients. Time is usually needed to work through the problems. Flexibility is key.

It is essential that implementation of a clinical information system not proceed to another nursing unit until existing units using the system are satisfied and running smoothly. Details must be settled before new fires are lit. If possible, I would suggest starting the implementation of clinical and CPOE systems with surgeons. Surgeons are more attuned to protocols and usually already have admission order sets for many types of surgical patients. Thus, it may be easier for them to transition to computerized ordering than internists, whose diverse patients tend to require customized orders and many more orders.

7. BEWARE OF UNINTENDED CONSEQUENCES

Computerization of clinical processes frequently exposes defects in long-standing practices and procedures. Such defects had been hidden by human workarounds and subtle fixes that the computer cannot replicate. Taking humans (usually nurses) out of the loop exposes problems and can make them worse.

Dr. Peter Provonost is an internationally known safety expert from Johns Hopkins Hospital. At a recent critical care conference, he described his experience consulting for four hospitals in the implementation of CPOE. He said that for two of those hospitals, the frequency of adverse drug reactions and medication errors rose dramatically after the CPOE system was implemented. He was alarmed and went so far as to make a personal call to

the chief executive officers of those hospitals to make sure they knew what was happening. He recommended that a hospital's manual processes of ordering and delivering medications not be discarded while the new system was being implemented because the abrupt transition to a computerized system can create very serious errors.

At Cedars-Sinai, we experienced an almost humorous example of an unintended consequence of clinical computerization. In the early 1990s we implemented an electronic urimeter interface so the nurses did not have to manually measure urine output or core body temperature. A single container connected to a Foley catheter held several liters of urine and had to be emptied only once during the day. It continuously measured urine output and core temperature in a totally closed, sealed system, and it automatically reported values to the computerized flowsheet. Aside from the efficiency improvement, the system proved useful in decreasing the rate of ICU urinary tract infections; our rate is a fraction of the national rate.

Since the new system seemed like a vast improvement for everyone involved, I was surprised to visit one of my patients in the ICU one day and hear a nurse complain about how much work it added to her day. She explained how every hour she had to clamp the tubing, come back later, sterilize the sampling port and then extract some urine with a sterile syringe and needle for the hourly specific gravity test, which the nurses ran at the bedside. I had been director of the surgical ICU for several years at that point and had not realized that the nurses were doing specific gravity tests hourly on all patients. Although I did not believe the tests were needed, the nurses associated the tests with quality patient care. The surgical ICU joint practice committee met and, after considerable discussion, finally agreed that specific gravity would be measured only upon physician order. On a given day the nurses stopped documenting hourly specific gravity, and not a single physician noticed. The new technology had brought to everyone's attention an unnecessary process that had been taken for granted.

Other examples of unintended consequences are less humorous. In a recent publication, Dr. Joan Ash and colleagues described the "midnight problem" associated with most CPOE systems (9). It does not matter clinically if most tests or medications for new patients are ordered just before or just after midnight. However, if a patient's evening admission is delayed until just after midnight, perhaps due to a busy emergency department or a bed shortage in the hospital, orders for tests or medications checked in the computer to start "tomorrow AM" will not take effect for another 24 hours. This may seem to defy common sense, but common sense is a quality computers lack. Physicians think about their workflow and nurses think about theirs, but all other workflows must be considered to avoid unintended and adverse consequences.

8. BE WARY OF UNCOVERING LONG-STANDING PROCESS FLAWS

Most manual systems and procedures have flaws that have been patched over so that no one is aware of them on a day-to-day basis. Ash also described problems related to orders for emergency department admissions (9). Clinical computer systems require patients to be uniquely identified and registered before data can be entered and certainly before orders can be written. While such identification ensures that orders are not written for the wrong patient, which could be disastrous, it also precludes writing computer orders for the entire length of time it takes to register a patient. In some hospitals and with some admission systems, registration can take a long time. This might be considered a process problem; however, it is completely masked in hospitals using traditional handwritten paper orders. In such a hospital or emergency department, even before a patient is registered or admitted to the hospital, physicians write orders on blank order sheets with the patient's name temporarily handwritten in. There is no computer equivalent for this manual step. As a result, physicians cannot write orders and have difficulty obtaining diagnostic tests, x-rays, and medications in a timely way. In an instant, a long-standing process flaw has been uncovered, and it is likely to be blamed on the new clinical system, even if the root cause is in another system or process.

9. DON'T DISRUPT "MAGIC NURSING GLUE"

All hospitals are held together with what I call "magic nursing glue." Nurses fix all the defects in physicians' orders. They fill in what is missing. When patients are transferred, they make the transfer go smoothly even if the orders are not perfect. Their workflow can be disrupted with a clinical system because the system can take nurses out of the loop.

Just as admission orders from the emergency department can be a problem, so can transfer orders. JCAHO regulations require that orders be rewritten when patients transfer to different levels of care. However, certain orders span multiple levels of care and are written by specific physicians, such as orders for epidural morphine. A CPOE system has a hard time knowing which orders span multiple levels of care and which have to be rewritten as the patient progresses. In the world of paper orders, nurses fixed these issues as part of their normal work, and physicians did not worry or even know about them. Clinical computer systems can also lead to a problem Ash calls "overcompleteness," in which everything has to be specified by a physician or nurse in minute, tedious detail (9). In addition, solutions that work in one part of the hospital do not necessarily work the same or as well in another part of the hospital. A new clinical system, with one way of doing things, is likely to disrupt "magic nursing glue" all over the hospital. In some cases the nurses' workflow can be changed, but in other cases the system has to be changed.

10. SPEED IS EVERYTHING

I come back to the speed issue because speed is everything to clinical users. Most practicing physicians—certainly physicians at large tertiary care centers like Baylor University Medical Center and Cedars-Sinai—are very busy. Their clinical day may start at 6:30 AM and may not be finished until 6:30, 7:30, or 8:30 PM. These physicians have already optimized their workflow just to get to the end of the day. Something that slows down their work becomes a major problem.

One study in the literature shows that entering orders into a computer can be time neutral; all other studies show that it costs physician time. One hospital handled the time issue by hiring a physician assistant to go on rounds and enter orders. Residents have complained at some hospitals that they end up performing

the technology-related tasks, which takes time away from educational aspects of their training.

LOOKING TO THE FUTURE

Baylor certainly has no problem with leadership. The institution has nationally renowned leaders in health care informatics and other areas. A problem you may face in the future is what I call "followership." Physicians in particular aren't always known for marching well. Both excellent leaders and excellent followers will be needed to make the new clinical information system a success.

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